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OBSERVATIONS OF NAPHTHALENE SCINTILLATIONS DUE TO TRITIUM BETA RAYS

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It seems desirable to report here some preliminary observations on the scintillations produced in commercial naphthalene by the beta rays from tritium and by the bremsstrahlung coming from tritium occluded in tantalum. Of immediate interest is the lower limit set on the conversion efficiency from beta ray to visible light energy.

A small amount of gaseous tritium was put in direct contact with finely powdered naphthalene crystals in a 15 cm^3 glass Kjeldahl flask, an identical flask but without tritium being used as a control, to find the direct action of the betas. A tantalum disk containing tritium occluded throughout its volume was placed near a solid piece of naphthalene to investigate the effect of soft x-rays since this is almost a pure source of such radiation. Both sources produced scintillations which were observed with a 1P21 photomultiplier, the pulses amplified by a Los Alamos Model 501 amplifier. The photomultiplier was not refrigerated. The rise time and total pulse length, easily observed on a 248A Dumont scope were respectively 0.05 μ secs and 0.2 μsecs. The gas concentration was not well known because the initially too high counting rates necessitated two depletions.

Only integral pulse height data have been taken and a representative bias curve is shown in Figure 1, together with a background using the dummy naphthalene cell. The "no naphthalene" background is considerably lower, presumably a result of a low gamma intensity about the laboratory. For at least the higher half of the pulse height curve the pulses are definitely not due to "pile up" and must be considered true individual counts.

If one assumes that the maximum energy betas from tritium have 15 kev then, very conservatively, individual pulses down to at least 10 kev beta energy are being observed. Since experiments are being designed to determine the absolute conversion efficiency with accelerated electrons of about this energy, detailed calculations are not worth while at present, but an estimate leads to the following numbers. We can assume roughly 1 electron going thru the multiplier and making a pulse for about 20 photons on the average striking the cathode. In the geometry used by us, somewhat less than 10% of all photons produced could be seen by the photomultiplier cathode; if these photons are of about 3 ev and are produced by a 10 kev beta, then a lower limit on the conversion efficiency is 6%. This seems to us to be a conservative limit.

The comparatively large energy conversion and the possibility of increasing the light collected by a factor of 5 or more raised the interesting question of the possibility of using this method to study beta ray spectra, in particular that of tritium. Over a short energy interval, say 15 or 20 kev, it seems reasonable to suppose that the conversion efficiency should vary only slowly, and this can be checked experimentally. The immediate attraction for low energy betas is that for gases or finely divided solids the source is always "thin." The greatest difficulty arises from the expected large output-pulse-height spread from a fixed number of incident photons. For single particles incident on a first stage, this is known to be large[1] and a lower limit on the dispersion is undoubtedly set by the statistics of the multiplication process which gives a mean pulse height spread of about $\sqrt{2}/\sqrt{n}$ instead of $1/\sqrt{n}$ where n is the number of electrons made in the first stage. Clearly, if a large number of particles (photons) simultaneously initiate a pulse this statistical spread can be greatly reduced. The spread

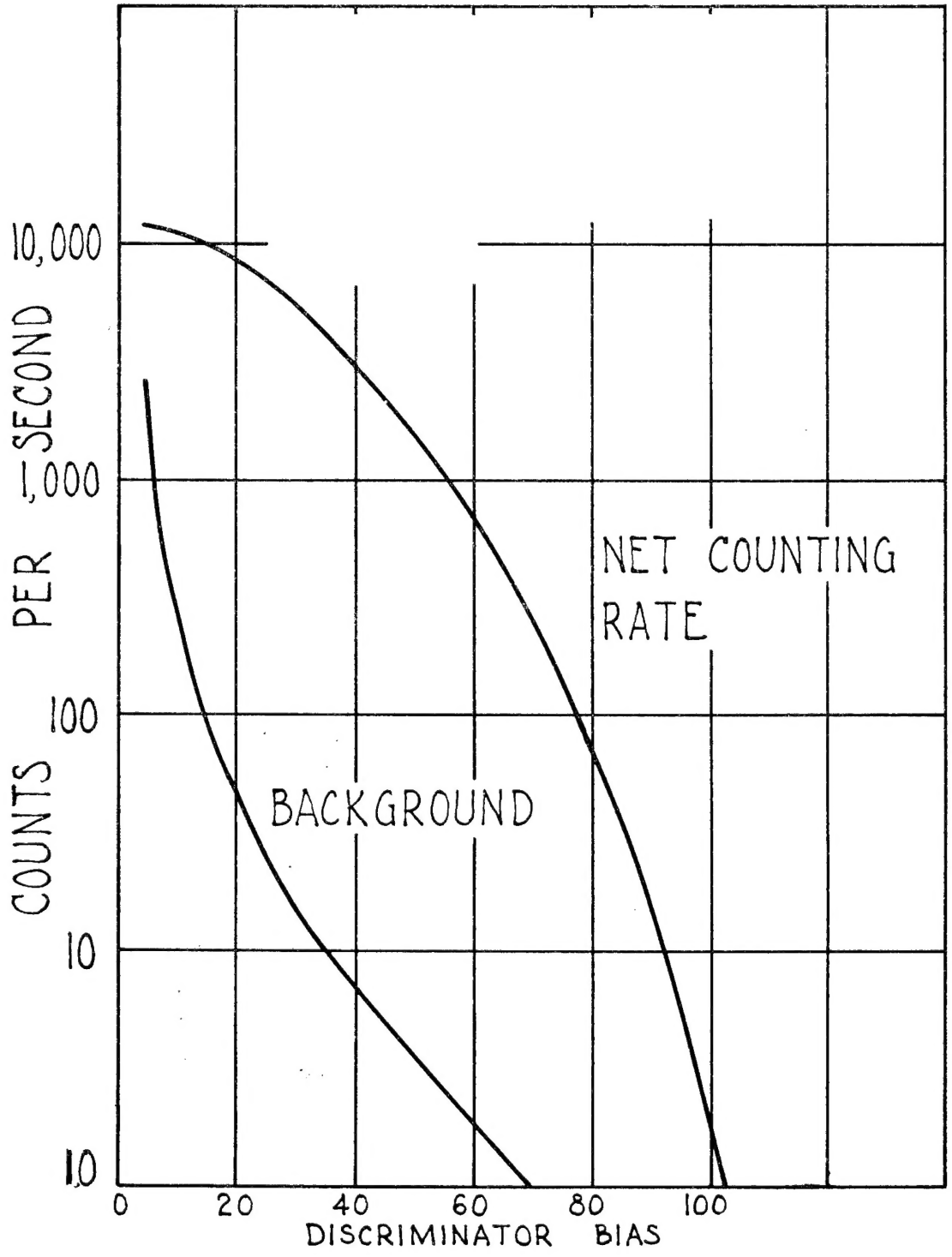

Figure 1. Integral bias curve—naphthalene and IP^{21} with and without tritium.

introduced by the photomultiplier design itself is as yet unknown but may render the method worthless. Experimental effort is presently directed toward maximizing the solid angle of observation to make use of as many photons as possible and toward the use of anthracene[2] and other scintillating materials for increasing the conversion efficiency. It is planned to study the pulse height distribution arising from monoenergetic electrons incident on anthracene.

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2. Bell, P. R., Phys. Rev., 73:1405, 1948.

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